

ECOSTRESS Science and Applications Team Meeting
November 15-17, 2022

**WIDESPREAD RACE AND ETHNICITY DISPARITIES WITH RESPECT TO
SOCIAL AND ENVIRONMENTAL INEQUITY ISSUES ACROSS MAJOR
CITIES IN THE US SOUTHWEST**

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Positioning the Problem

- (i) US Southwest, characterized by the **hottest and driest region** in the US, presents a climate change challenge to sustainable development by human and natural systems.
- (ii) In this context, how inequality shifts among **races/ethnicities** with climate change is unclear.
- (iii) **Vulnerable groups** (such as marginalized communities and racial/ethnic minorities) occurring heat-related mortality and morbidity commonly present higher risk.
- (iv) Whereas characteristics of the built environment not only generate the **spatial difference of heat exposure between different communities** but also contribute to disparities of **available water consumption**, thus highlighting social and environmental inequities
- (v) Social and environmental inequities bring enormous challenges for the United States as this phenomenon commonly contributes to various **public security and health issues**.

Objectives

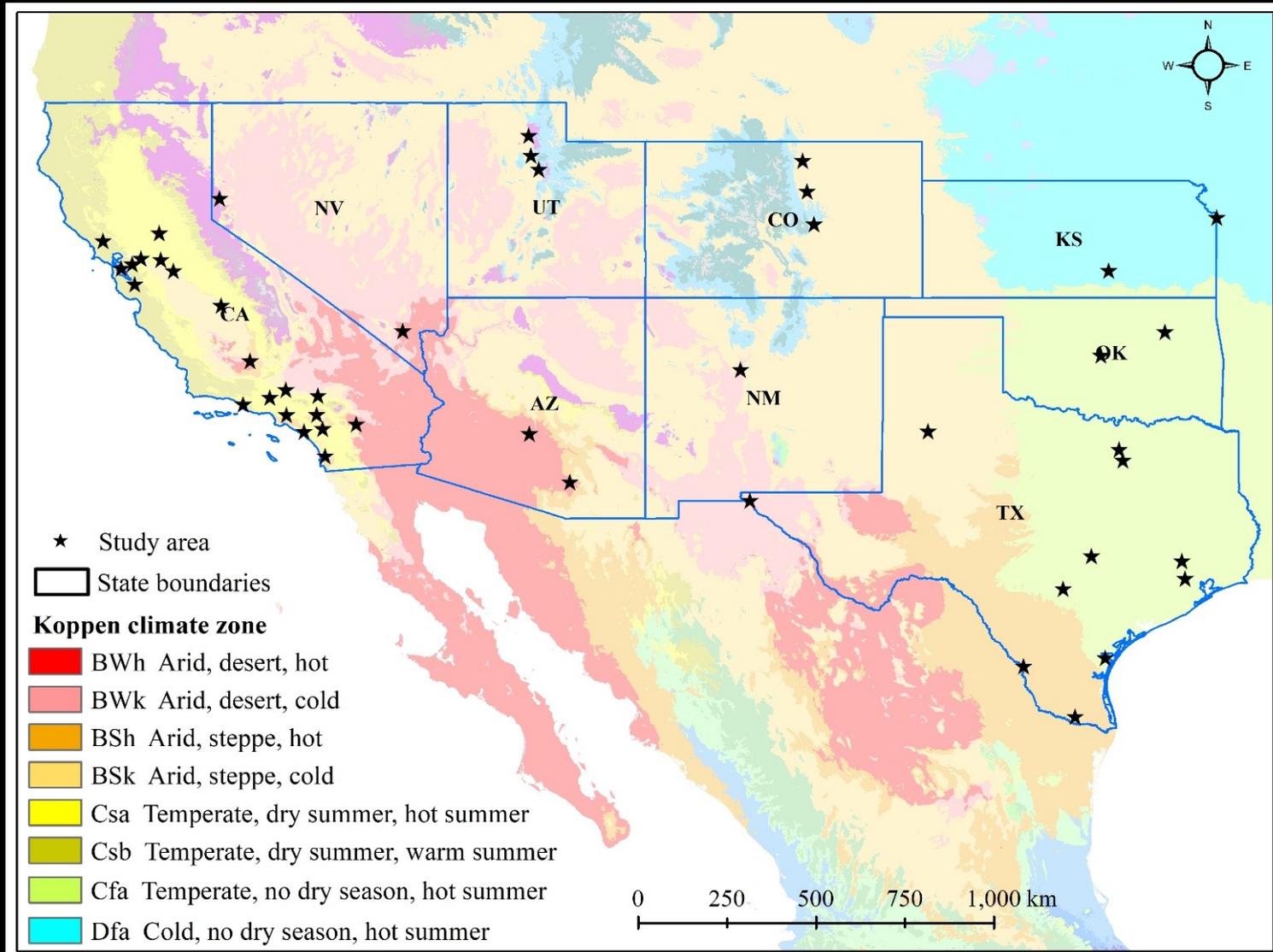
The specific objectives of this study are to

- (i) examine the widespread disparities of multi-directional factors (the social economy and environmental changes) among races/ethnicities,**
- (ii) dynamically analyze how inequality changes among races/ethnicities by quantifying environmental differences over time,**
- (iii) evaluate the impact of climate changes on environmental inequalities in the past 20 years, and**
- (iv) provide recommendations for the development of sustainable and equitable policies.**

Data

- (i) We focus on all major US Southwest urban areas at the Census block group level. We assign the mean values of all social-economic and environmental variables to each boundary at the selected **US Census block groups (BGs)**.
- (ii) Arizona (AZ), New Mexico (NM), California (CA), Colorado (CO), Kansas (KS), Nevada (NV), Oklahoma (OK), Texas (TX), and Utah (UT). The boundaries of the **46 largest urban areas** from a total of these nine states are selected based on the census-defined urbanized areas that contain **more than 250,000 residents**.
- (iii) We also collect the **Köppen-Geiger climate zones** to explore whether environmental inequality exists in differences in different climate zones

Study Areas/Cities



46 cities in the study area.

Category	Race/Ethnicity	Abbreviation
Race	White alone	WHI
	Black or African American alone	BLA
	American Indian and Alaska Native alone	AIA
	Asian alone	ASI
	Native Hawaiian and Other Pacific Islander alone	NHO
	Two or more races	TMR
Ethnicity	Hispanic or Latino	HIS
	Non-Hispanic	NHIS

$$DI = 1 - (\%WH^2 + \%BL^2 + \%AA^2 + \%AS^2 + \%HP^2 + \%TR^2) \times (\%HI^2 + \%NH^2)$$

Where DI represents the **diversity index (DI)**, %WH, %BL, %AA, %AS, %HP, %TR, %HI, and %NH represent the corresponding racial/ethnic percentage of the total population at each block group.

We also create a **People of color (PEC)** category - including all Hispanic and all populations that do not identify as white alone, and its complementary set – non-Hispanic white (NHW)

Ecology/Environmental Database (ECOSTRESS Data)

(1) Land Surface Temperatures (LST)

(2) Evapotranspiration (ET)

(3) Evaporative Stress Index (ESI)

Environmental Change Database (Landsat)

- (1) We collect all available Landsat images with cloud cover lower than 75% in the summer from 2000 to 2020 to analyze LST and ETa changes.**
- (2) There are a total of 8,860 scenes (Landsat 4, 5, 7, and 8) to fully cover the study areas between 2000 and 2020.**
- (3) Landsat-based LST retrieval is computed using Statistical Mono-Window (SMW) algorithm developed by the Climate Monitoring Satellite Application Facility (CM-SAF).**
- (4) For Landsat-based ETa retrieval, the operational version of Simplified Surface Energy Balance (SSEBop) is used to construct ETa maps of the study area.**
- (5) We applied Mann-Kendall (MK) analysis test to examine the time series change trend.**

Social-environmental metrics by races/ethnicities across 46 major cities in the US Southwest

Variables		Race					DI
		White	Black	Native	Asian	N Hawaiian	
Social economy	+MHI (K\$)	79.88 (0.38**)	64.74 (-0.28**)	64.75 (-0.31**)	80.96 (0.32**)	68.62 (-0.06**)	- (-0.39**)
	+PCI (K\$)	37.25 (0.5**)	28.68 (-0.24**)	28.11 (-0.31**)	35.97 (0.21**)	29.99 (-0.11**)	- (-0.48**)
	-PHBPL	0.12 (-0.41**)	0.17 (0.26**)	0.16 (0.24**)	0.12 (-0.16**)	0.15 (-0.01)	- (0.29**)
	+MHPV (K\$)	363.12 (0.12**)	294.62 (-0.23**)	285.16 (-0.25**)	358.77 (0.47**)	304.01 (-0.03**)	- (-0.22**)
Environment	-Daytime LST (°C)	43.6 (-0.13**)	44.25 (0)	44.25 (0.15**)	43.9 (-0.16**)	44.33 (0.04**)	- (0.2**)
	+ESI	0.46 (0.08**)	0.447 (0.25**)	0.449 (-0.12**)	0.449 (-0.15**)	0.448 (-0.22**)	- (-0.09**)
	+ETa (W/m ²)	311.4 (-0.09**)	308.56 (0.26**)	309.58 (-0.12**)	309.26 (0)	307.36 (-0.13**)	- (0.06**)
Environmental Change	-LST Sen's slope (°C/year)	0.109 (-0.17**)	0.109 (-0.23**)	0.114 (0.12**)	0.107 (0.08**)	0.113 (0.08**)	- (0.16**)
	+ETa Sen's slope (mm/year)	-0.00346 (-0.07**)	-0.00434 (-0.11**)	-0.00518 (-0.05**)	-0.00284 (0.06**)	-0.00444 (-0.04**)	- (0.11**)

MHI: Median household income; PCI: Per capita income; PHBPL: Percentage of household below the poverty level; MHPV: Median household property values. The correlation of percentage of races/ethnicities and DI against the variables are in parentheses (*p < 0.05, **p < 0.01).

Weighted means of social-environmental metrics by contrary groups of races/ethnicities across major US Southwest cities (46 cities).

Variables		Contrary groups			
		HIS	NHIS	PCOL	NHISW
Social economy	+MHI (K\$)	64.63 (-0.51 ^{**})	79.68 (0.51 ^{**})	68.31 (-0.44 ^{**})	82.71 (0.44 ^{**})
	+PCI (K\$)	27.66 (-0.59 ^{**})	36.81 (0.59 ^{**})	29.71 (-0.56 ^{**})	38.96 (0.56 ^{**})
	-PHBPL	0.16 (0.45 ^{**})	0.12 (-0.45 ^{**})	0.15 (0.45 ^{**})	0.11 (-0.45 ^{**})
	+MHPV (K\$)	283.47 (-0.38 ^{**})	360.77 (0.38 ^{**})	303.82 (-0.21 ^{**})	376.2 (0.21 ^{**})
Environment	-Daytime LST (°C)	44.3 (0.27 ^{**})	43.68 (-0.27 ^{**})	44.18 (0.17 ^{**})	43.51 (-0.17 ^{**})
	+ESI	0.448 (-0.08 ^{**})	0.458 (0.08 ^{**})	0.449 (-0.05 ^{**})	0.462 (0.05 ^{**})
	+ETa (W/m ²)	309.49 (-0.01)	312.32 (0.01)	309.92 (0.1 ^{**})	311.82 (-0.1 ^{**})
Environmental Change	-LST Sen's slope (°C/year)	0.114 (0.24 ^{**})	0.108 (-0.24 ^{**})	0.112 (0.17 ^{**})	0.108 (-0.17 ^{**})
	+ETa Sen's slope (mm/year)	-0.00495 (0.12 ^{**})	-0.00329 (-0.12 ^{**})	-0.00447 (0.09 ^{**})	-0.00331 (-0.09 ^{**})

HIS: Hispanic or Latino; NHIS: Not Hispanic or Latino; PCOL: People of color; NHISW: Not Hispanic or Latino White alone

MHI: Median household income; PCI: Per capita income; PHBPL: Percentage of household below the poverty level; MHPV: Median household property values

Note: The correlation of percentage of races/ethnicities and DI against the variables are in parentheses (*p < 0.05, **p < 0.01). + means positive indicators that the higher values are better, and – indicates negative indicators that the lower values are better.

Examining difference in mean among different races/ethnicities across major US Southwest cities using paired-sample T-test (inter-city, 46 urbanized cities)

Races/ethnicities		Contrary groups	
		Hispanic vs. non-Hispanic	People of color vs. non-Hispanic white
Social economy	+MHI (K\$)	-15.05**	-14.14**
	+PCI (K\$)	-9.15**	-9.25**
	-PHBPL	0.039**	0.043**
	+MHPV (K\$)	-77.31**	-72.38**
Environment	-Daytime LST (°C)	0.617**	0.665**
	+ESI	-0.00966**	-0.0131**
	+ETa (W/m ²)	-2.83	-1.86
Environmental Change	-LST Sen's slope (°C/year)	0.00620**	0.00366**
	+ETa Sen's slope (mm/year)	-0.00167**	-0.00116*

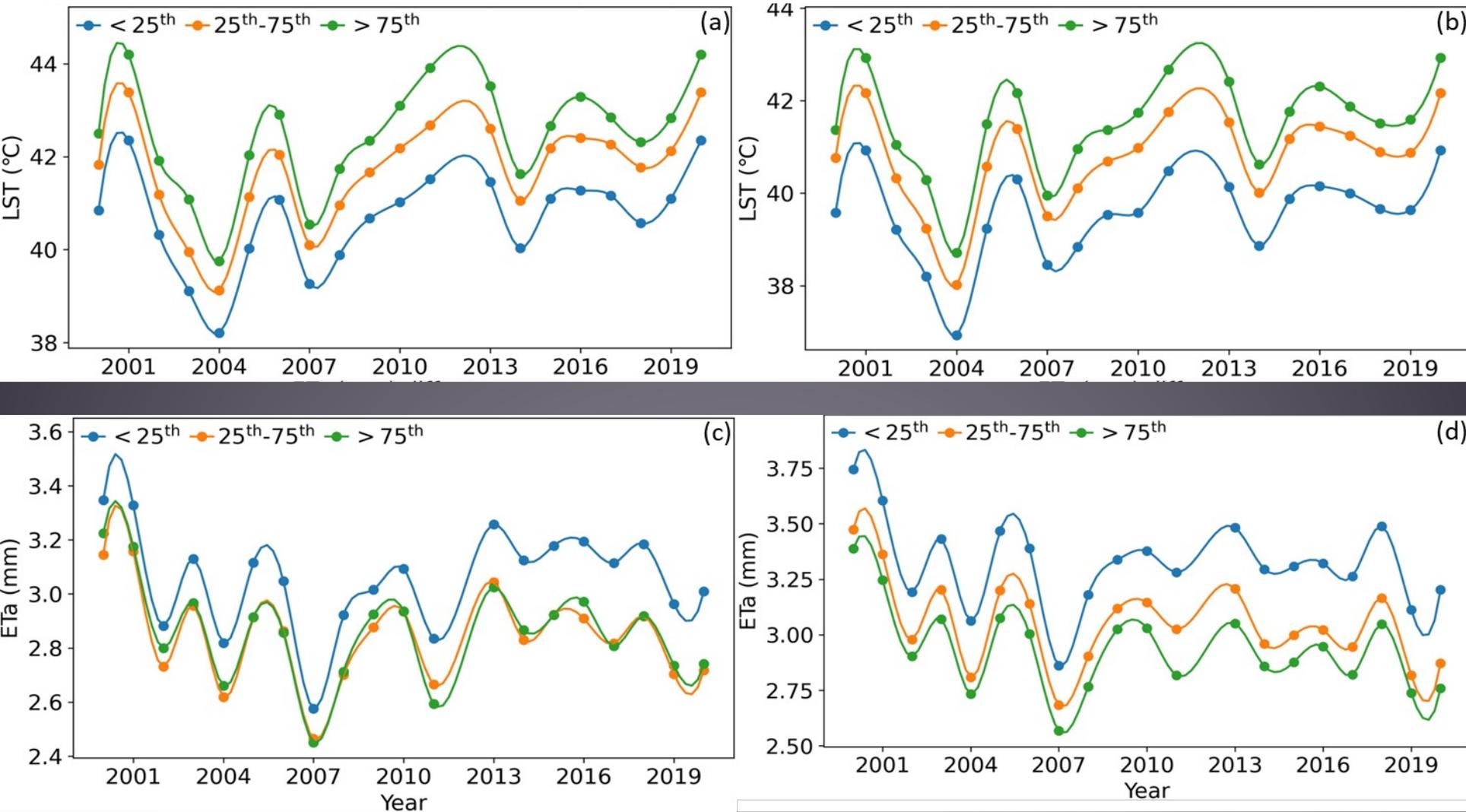
The values represent the differences in inter-city means across the contrary groups.

“+” implies positive condition - the higher value the better the condition (**except those for LST**).

“-” represents negative condition - the lower the value the better the condition

*p < 0.05, **p < 0.01

The time series of LST and ETa annual mean from 2000 to 2020 of contrary groups



Hispanic vs. non-Hispanic

People of color vs. non-Hispanic white

Note: $< 25^{\text{th}}$, $25^{\text{th}} - 75^{\text{th}}$, and $> 75^{\text{th}}$ represent the areas with a population of Hispanic and people of color lower than 25^{th} (non-Hispanic and non-Hispanic-white-dominated regions), between 25^{th} and 75^{th} (ethnically/racially diverse areas) and **higher than 75^{th} (Hispanic and people of color-dominated neighborhoods)** at the city level, respectively.

Mean values of LST and ETa from 2000 to 2020 in connection with two climate zones (Arid, Temperate, and Cold) across different areas for contrary groups.

Arid

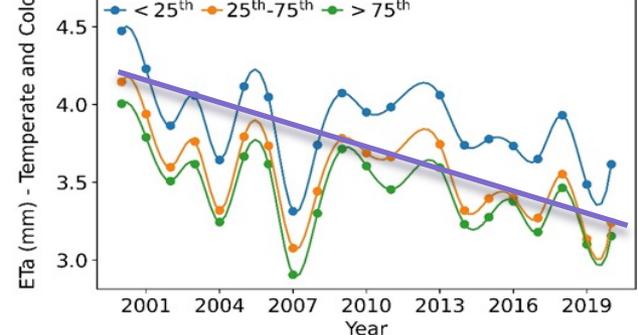
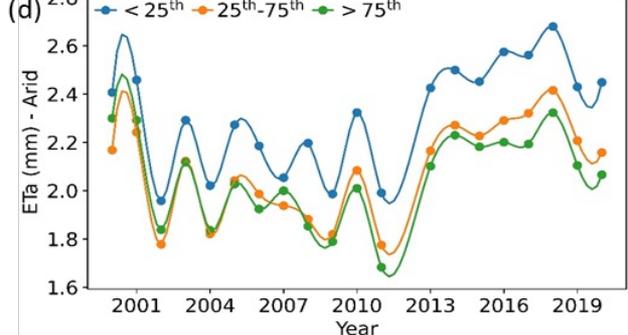
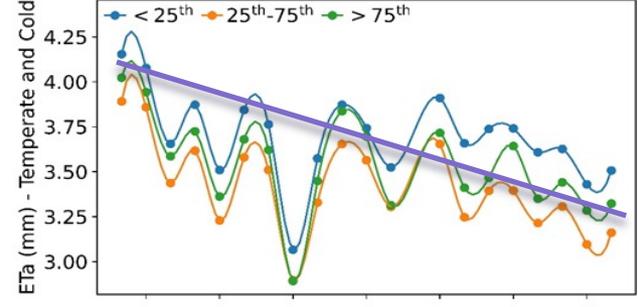
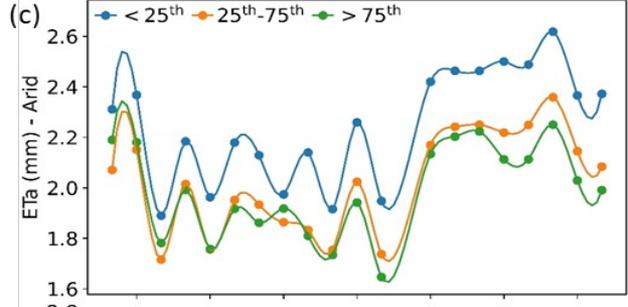
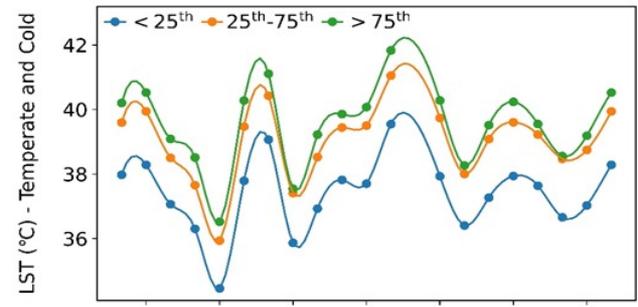
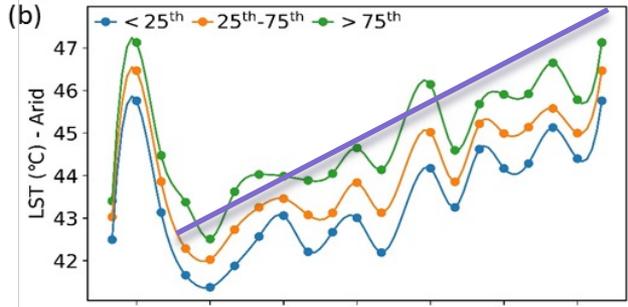
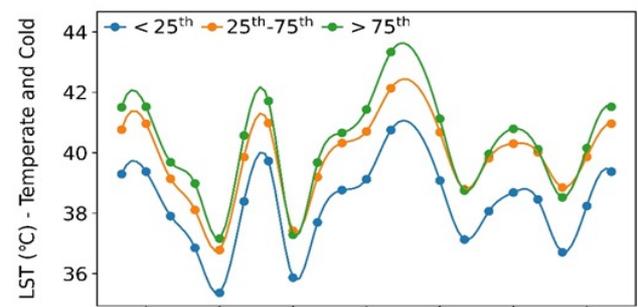
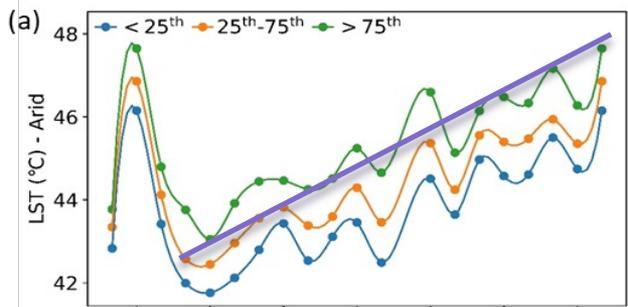
Temperate/Cold

Hispanic vs. non-Hispanic

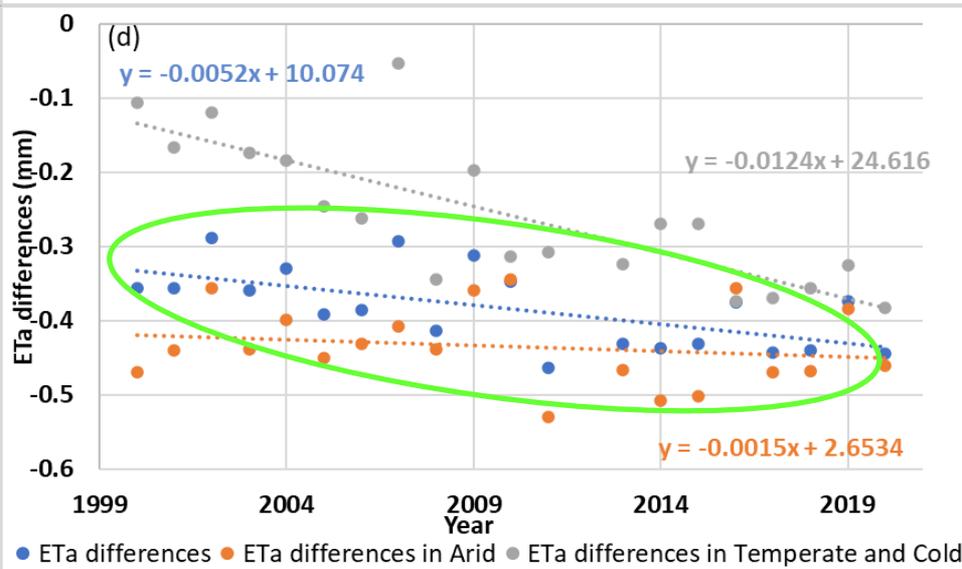
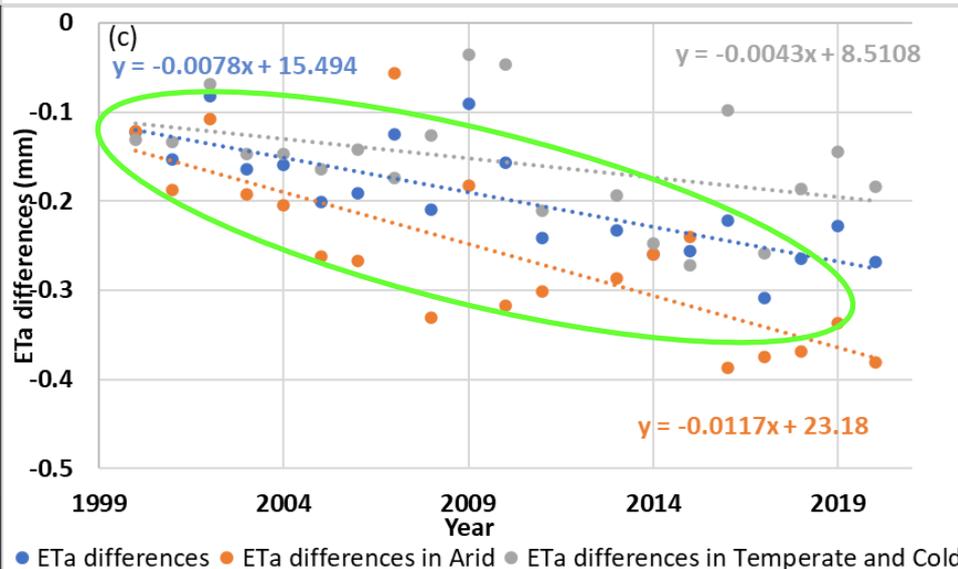
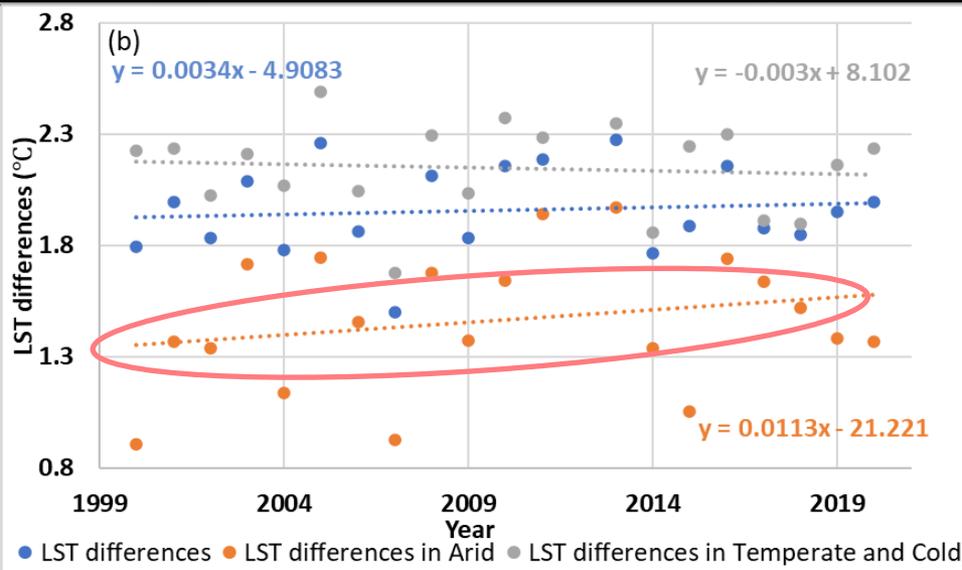
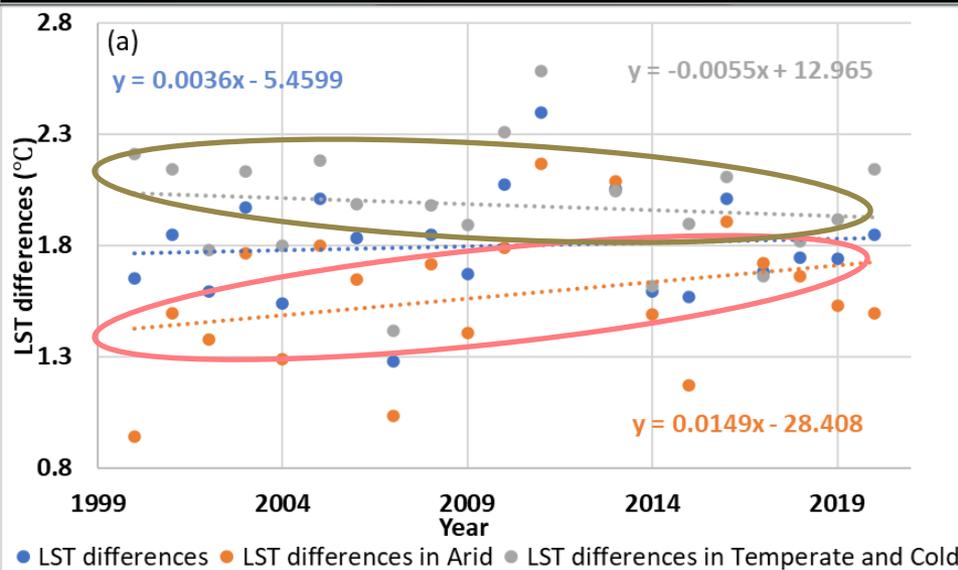
People of color vs. non-Hispanic white

Hispanic vs. non-Hispanic

People of color vs. non-Hispanic white



LST and ETa differences between 2000 and 2020



Hispanic vs. non-Hispanic

People of color vs. non-Hispanic white



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November 16, 2022

Dataset Restricted Access

Widespread Race and Ethnicity Disparities with respect to social and environmental inequality problems across major US Southwest urban areas

Myint, Soe; Zhu, Yuanhui; Li, Yubin

This study aims to provide insight into the US Southwest social and environmental inequality problems by combining high-resolution ECOSTRESS data, including Land Surface Temperature (LST), Evaporative Stress Index (ESI), and actual Evapotranspiration (ETa) with sociodemographic data at the block group level acquired from US Census. ESI and ETa represent drought and consumptive water use, respectively. Further, disparities of environmental changes over the past two decades in connection with races/ethnicities are explored using Landsat-based LST and ET from 2000 to 2020 across major US Southwest cities in light of global climate changes. We narrow our investigations to the summer months, including June, July, and August, when environmental issues are more pronounced during the day, such as heat-related mortality and morbidity and higher water consumption.

The dataset description

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Widespread Race and Ethnicity Disparities with respect to social and environmental inequality problems across major US Southwest urban areas

Myint, Soe; Zhu, Yuanhui; Li, Yubin

This study aims to provide insight into the US Southwest social and environmental inequality problems by combining high-resolution ECOSTRESS data, including Land Surface Temperature (LST), Evaporative Stress Index (ESI), and actual Evapotranspiration (ETa) with sociodemographic data at the block group level acquired from US Census. ESI and ETa represent drought and consumptive water use, respectively. Further, disparities of environmental changes over the past two decades in connection with races/ethnicities are explored using Landsat-based LST and ET from 2000 to 2020 across major US Southwest cities in light of global climate changes. We narrow our investigations to the summer months, including June, July, and August, when environmental issues are more pronounced during the day, such as heat-related mortality and morbidity and higher water consumption.

The dataset description

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Category	Datasets	Resolution	Source/method	Time
Boundary datasets	US Southwest urban areas	US Census block groups	US Census	2018
Demographic Data	Race/ethnicity	Block group level	US Census	2020
Socioeconomic data	Median household income	Block group level	US Census	2020
Socioeconomic data	Per capita income	Block group level	US Census	2019
Socioeconomic data	Poverty status of household	Block group level	US Census	2019
Socioeconomic data	Median household property values	Block group level	US Census	2019
Environmental database	Daytime Land Surface Temperature (LST)	70m	ECOSTRESS	2020
Environmental database	Actual Evapotranspiration (ETa)	70m	ECOSTRESS	2020
Environmental database	Evaporative Stress Index (ESI)	70m	ECOSTRESS	2020
Environmental change database	LST changes (Sen's slope)	30m	Landsat-based Statistical Mono-Window algorithm	2000-2020
Environmental	ETa changes (Sen's	30m	Landsat-based Simplified Surface	2000-2020

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Versions

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Thank you!